

DEVELOPMENT OF OCCUPANT CLASSIFICATION SYSTEM

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● ABSTRACT

An Occupant Classification System (OCS) that detects the existence and physique of the passenger seat occupant for the Advanced Air Bag requirements of FMVSS208 was developed.

This paper describes an OCS which distinguishes small women (5th percentile adult female dummy: AF05) from young children (less than 6-year-old child dummy: AC06) pertaining to the following items.

- (1) The reason of classification between AF05 and AC06.
- (2) The relation between the occupant seating position and OCS output.
- (3) An influence on the OCS output of the belt tension load and the way of compensation it.

This sensor system satisfies the suppression requirements of the FMVSS208.

Additionally, other seating positions which Nissan considers important in Real World can also be detected.

● INTRODUCTION

In May 2000, NHTSA published in the Federal Register (65 FR 30680) a rule to require advanced air bags. They are intended to create less risk of serious air bag-induced injuries, particularly for small women and young children.¹

During the first stage phase-in, from September 1, 2003, to August 31, 2006 increasing percentages of motor vehicles will be required to meet requirements for minimizing air bag risks.¹ Nissan has been proceeding with research and development for the sensing system which can detect occupant classification by measuring weight on the seat. This sensor system enables compliance with automatic suppression requirements of FMVSS208 and Real World requirement.

This paper describes about OCS and its performance.

● The classification of the occupant detection

The option chosen by Nissan from FMVSS208 requirements is shown Figure 1. The airbag system is designed to operate for occupants AF05 and larger and is designed to suppress for occupants AC06 and smaller.

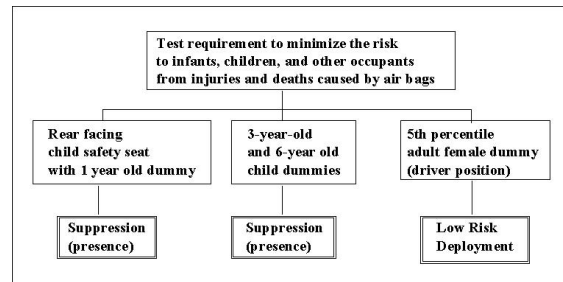


Figure 1. The option chosen by Nissan from FMVSS208 requirements

● Sensor system

The system differentiates between the weight of the child (AC06 and smaller) and AF05 which are described in regulations. There are unique challenges in accomplishing this, however.

(1) Child's seating posture

Because children's feet may not reach the floor, the weight of the child is entirely on the seat. Furthermore, if the child is in a Child Restraint Seat (CRS), this additional weight is also on the vehicle seat.

(2) Adult seating posture

Because adult's feet are set on the floor, the load on the seat becomes lighter than the adult's real weight. Approximately 20% of the adult's weight is supported by the floor in sedan type vehicles. This will change by the height of Hip Point and the seat shape.

The various dummy and human weights defined by FMVSS208 are shown in Figure 2.

		(kg)		
Physique		Weight	CRS MAX Weight	Total MAX Weight
12-month-old CRABI	Dummy	10.3	6.9	17.2
	Human	8.2 - 9.1	6.9	16
3-year-old child	Dummy	17	6.9	23.9
	Human	13.4 - 18	6.9	24.9
6-year-old child	Dummy	23.9	4.5	28.4
	Human	21 - 25.6	4.5	30.1

		(kg)		
Physique		Weight	weight applied to seat	Total Min Weight
5th percentile adult female	Dummy	47.9	9.6	38.3
	Human	46.7 - 51.25	9.3 - 10.25	37.4

Figure 2. Comparison of occupant weight

According to the Figure 2, child weight is not more than 30.1kg and adult weight is more than 37.4kg. There is a gap between child weight and adult weight. This gap in the weight can be distinguished by the sensor system.

The sensor system is shown in the Figure 3 and 4.

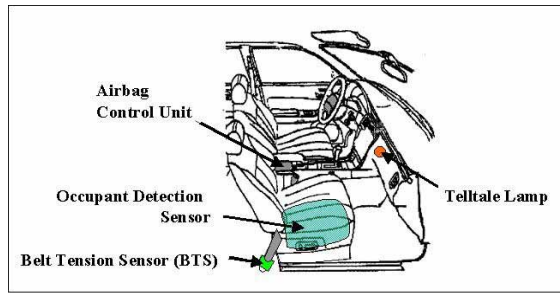


Figure 3. Sensing system

The load on the seat cushion is measured by the pressure detection mat, which is put between seat pan and cushion.

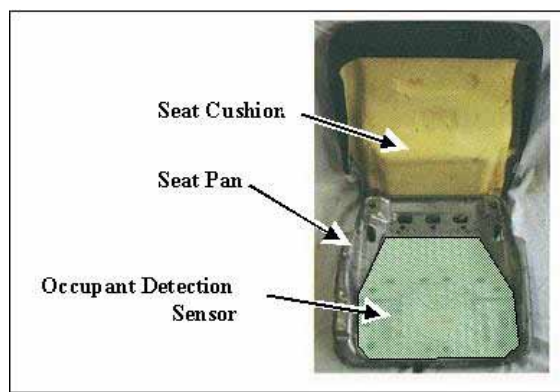


Figure 4. Structure of Sensor

● Detection performance

Confirmation of this sensor system was done using the FMVSS208 occupant detection requirements. A result of an analysis is shown in Figure 5. An adult (beyond AF05) and a child (less than AC06) have definite separation and can be distinguished.

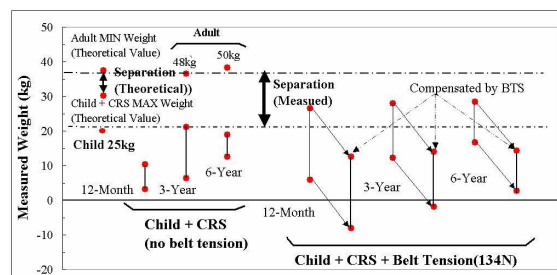


Figure 5. Result of experiment (FMVSS208)

As seen in Figure 5, the theoretical value used for the child and CRS was actually more conservative (higher) than when humans were used. The separation band was actually twice as large as it was theoretically calculated. One of the reasons for the larger separation was because the shape of child

restraints dispersed the load over a larger area and a portion of the force was transmitted to the seat pan, and not to the ODS. (See Figure 6)

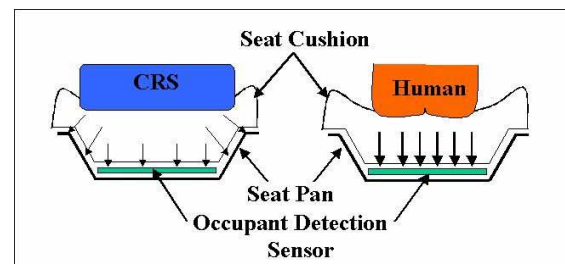


Figure 6. Sensing mechanism

This separation however is reduced when it is considered that the CRS is secured by a seat belt. (The belt tension condition for FMVSS 208 is 134N.) The belt tension load increases the measured weight of the CRS on the vehicle seat, shown on the right side of Figure 5. Figure 7 describes the relationship between belt tension and the increased seat load. To address this, a belt tension sensor (BTS) is used to monitor the belt tension, and a compensation formula (Figure 7) is used to recalculate the measured weight (Figure 5).

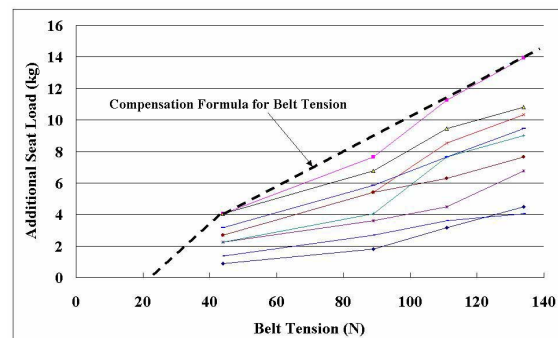


Figure 7. Compensation of belt tension

With this adjustment, the separation between the adult and children AC06 and smaller can be maintained.

Additional factors that influences sensor performance in Real World were also considered.

(1) Vibration by driving

Sensor output changes by an occupant's moving up and down during driving due to road surface unevenness and vibration of the vehicles.

The test result was shown in the Figure 8.

The direct output signal from the sensor has sharp fluctuations. However, the signal becomes more stable by using an electronic filter and logic.

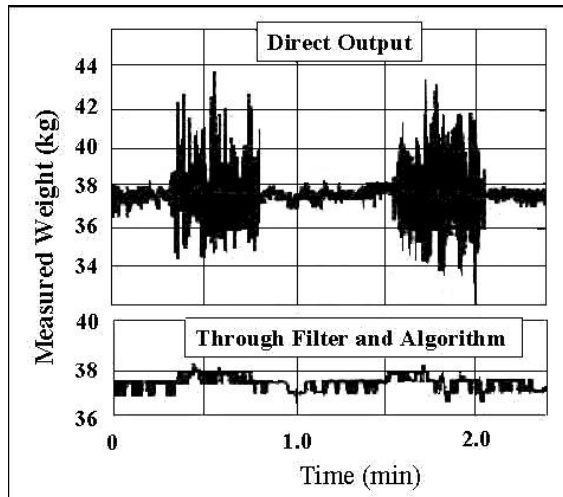


Figure 8. Influence of vehicle vibration

(2) Creep of the seat cushion

The load transmission characteristic of seat cushion urethane changes by slow degrees. This change occurs in a short time for 20-30 minutes, and it is restored after unload. The example of the change character is shown in Figure 9.

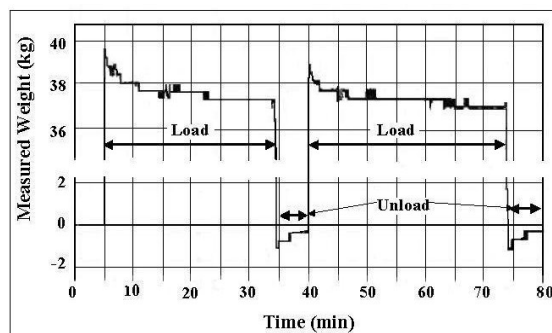


Figure 9. Influence of seat creep

(3) Deterioration

Using a seat for a long time, the load transmission character of the seat cushion changes due to cushion and trim cover deterioration.

A change of measured weight in the durability test is shown in Figure 10.

The measured weight declines slowly as the reaction force of the seat declines due to the deterioration.

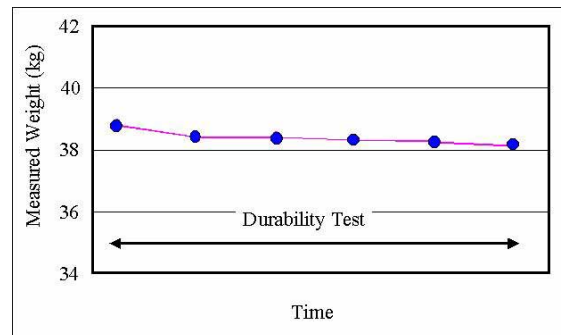


Figure 10. Influence of deterioration

(4) Others

Temperature, humidity and tolerance of parts also can influence the sensor performance.

The measurement weight includes measurement changes due to the above factors, and in Real World it is necessary to consider. The logic and sensitivity of the sensor is designed to minimize the above effects and to accurately classify the occupants.

● Seating Position

Nissan takes into consideration not only the requirements of FMVSS208 but also the situations that occur in Real World.

The points of selection as an evaluation posture were shown in the following.

- (1) Seating postures that can be maintained for long periods of time.
- (2) Common postures that can be maintained even for a short period of time.

The test result is shown in Figure11 that evaluate requirements of FMVSS208 and Real World condition.

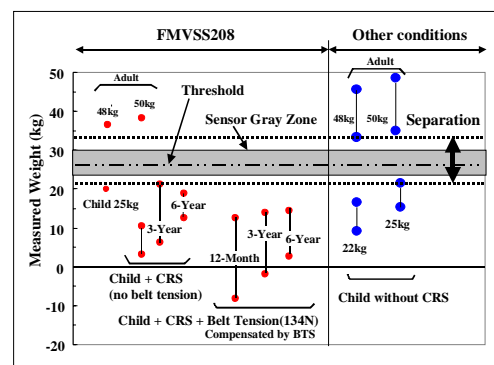


Figure 11. Result of experiment (FMVSS208 & Real World)

The elements mentioned above (vibration, creep,

deterioration and others) can influence the measured weight value. When the threshold for the sensor is set up, it must consider these influences. These influences were analyzed by experiments and are shown by Sensor Gray Zone in Figure 11. The separation between child and adult at the seating positions (requirements of FMVSS and Due Care which Nissan considered) is greater than the Sensor Gray Zone indicating that this sensor system can distinguish between the adult and child in Real World situations in addition to the requirements of FMVSS 208.

As previously explained, this system has been shown to be able to effectively classify various sized occupants in various seating postures in real world conditions. Nevertheless, certain occupants who are unusually or improperly positioned may not be able to be detected by the sensors. Therefore, information regarding such improper positions need to be explained in the vehicle's owners manual to educate the consumers. In addition to such information, a telltale lamp is incorporated into the instrument panel to alert the customer of the current airbag condition, whether it is 'on' or in a suppressed condition.

● Conclusion

The OCS described here can satisfy the requirements of FMVSS 208 and is effective in identifying the size of occupants seated in the right front seat. Despite its ability to differentiate various size occupants and meet FMVSS 208, Nissan continues to believe that all children 12 and under be properly restrained in the rear seat. Studies of real world crash performance have indicated that the rear seat environment has inherent advantages over the front seating locations and will continue to provide safety benefits for children 12 and under.

REFERENCES

- 1: Federal Register
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